Speak the beat: The effect of priming tones on speech production rate

Undergraduate Research Thesis

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Abstract

Will the rhythm of what you hear influence how you speak? The two current studies explore whether a priming rhythm, which has no melodic component, can influence speech production rate. In the first study, participants heard rhythmic beats consisting of different styles: cowbells, drips, heartbeats, pings, and a metronome. Following each sound sequence, the participants described the action in the cartoon-like picture. In the first study, when participants described the pictures, their rate of speech following faster sound primes was not significantly different from their rate following slower sound primes. Participants in the second study heard 20 steady rhythmic sequences consisting of one of five different sounds presented at either a fast or slow rate with 60% of the sequences including a changed tone. Participants pressed a button when they detected a change in pitch during the rhythmic sequence. Alternating between each rhythm sequence, participants described the action portrayed in the cartoon pictures. In the second study, the rate of the priming rhythm influenced button-press reaction time, but not speech rate. The results from both studies suggest the need for a richer sound prime.

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What we hear often influences our speech. For example, our speech can be influenced by music and language (Hupp & Jungers, 2009; Jungers et al., 2016). One aspect of language that influences our speech is prosody, which is the patterns of stress, intonation, rhythm, pitch, and rate in a language (Tooley et al., 2018). This means that the way that something is said can influence how we say something. Previous research suggests that the rate aspect of prosody can be used to prime an individual's rate of speech (Hupp & Jungers, 2009; Jungers et al., 2002).

The speech that we hear from others influences our speech in different ways. Past research has found that the speech rate of one person influences the speech rate of another (Hupp & Jungers, 2009; Jungers & Hupp, 2009). When individuals are primed with a speech rate, they will speak at rates that reflect the rate of the prime (Jungers et al., 2002). Previous research has also found that speakers are likely to persist in the pause length after recently heard utterances (Giles et al., 1991). Another study found that participants spoke faster and slower after hearing fast and slow prime sentences (Tooley et al., 2018). Previous research has also observed that when parents speak slowly to their stuttering children, the children slow down their rate of speech and their stuttering decreases (Guitar & Marchinkoski, 1991; Sawyer et al., 2017).

Previous studies have examined conversational entrainment. Conversational entrainment is when individuals' behaviors such as speech rate, vocal intensity, pitch properties, and vocal qualities, align unintentionally during conversations (Phillips-Silver et al., 2010; Wynn & Borrie, 2020). Conversational entrainment is often sustained in conversations, as it is important for communication (Borrie et al., 2019). For example, individuals who are having a conversation will adjust their behavior to match their conversational partner (Borrie et al., 2019).

Conversational entrainment has been observed in verbal and non-verbal aspects of conversations (Borrie et al., 2019). Speech rate is often examined as one of the conversational factors. For example, a previous study found that the slower the rate of the stimuli, the slower participants spoke, revealing that conversational entrainment was taking place (Wynn & Borrie, 2020). This has been seen in studies that utilize conversations as well. In one study, participants reduced their speech rate during a conversation when the researcher reduced their speech rate (Freud et al., 2018).

Individuals often use imitation as a social signal and to create social bonds (Krishnan-Barman & Hamilton, 2019). Imitation or mimicry also creates social cohesion and likeability among individuals (Chartrand & Bargh, 1999; Manson et al., 2013). Imitation and conversational entrainment are types of behavioral coordination (Manson et al., 2013). A previous study observed that when conversational entrainment took place among participants, the participants were more likely to exhibit prosocial behavior (Manson et al., 2013). It has also been observed that patrons will leave a larger tip to waitresses who mimic the patrons (van Baaren et al., 2003). A previous study also found that phonetic convergence in college roommates is related to the closeness of their relationship (Pardo et al., 2012). Individuals may be using conversational entrainment unintentionally to imitate and create social bonds (Pardo et al., 2012).

Music plays a large role in our everyday lives. It has been observed that music and language are linked together with the rhythmic structure of music and language influencing each other (Palmer & Kelly, 1992). Aside from being a form of entertainment, music has been found to influence speech and behavior (Jungers et al., 2016). Past research has found that the rate of music heard influences the rate of speech in individuals (Jungers et al., 2016). This means that faster music produces faster speech rates and slower music produces slower speech rates.

Previous studies have also found that the rate of an auditory prime, both for sentences and melodies, influences sentence production rates in individuals (Jungers et al., 2016; Jungers & Hupp, 2018). Music can also affect speech production and perception. A past study found that music-like rhythmic priming enhanced perception and speech production in children (Cason et al., 2015). Additionally, listening to music-like rhythmic primes led to better phoneme detection (Cason, Astésano et al., 2014). This means that the rhythms in the music provide enough information for entrainment to take place (Large & Jones, 1999).

The goal of the current studies is to ascertain if a metronome-like priming rhythm can influence speech production rate. More specifically, we examined how different rates of a metronome-like prime composed of different sounds influenced the speech rate of participants' spoken sentences. In the first study, participants heard fast and slow metronome-like priming rhythms and described cartoon-like pictures out loud. In the second study, participants also heard fast or slow metronome-like priming rhythms and described cartoon-like pictures out loud. However, participants also heard a change in sound in the metronome-like priming rhythm and pressed a button to indicate that they heard the change in sound.

The reaction time to the change in sound was used as a manipulation check to see if the participants were paying attention to the metronome-like prime. The change in sound was also used to see if the participants are entraining to the beat in the metronome-like prime. Entrainment is when separate rhythms interact and align with each other (Clayton, 2012). It has been observed that a synchronized motor response is elicited when listeners hear a beat (Nettl, 2000). It has been suggested that internal rhythms are responsible for human behavior entraining to the environment around us (Jones & Boltz, 1989; Large & Jones, 1999). Thus, reaction time to the changed sound was measured with a button press because rhythmic beats influence individual's motor behavior (Patel, 2006).

From previous research, we know that primes that have a melodic or tonal component influence speech production rate (Jungers et al., 2016). We also know that speech primes influence speech production rate (Hupp & Jungers, 2009). It is not known if primes that do not have a melodic or tonal component can influence speech production rate or behavior. Because past research has found that speech and musical primes influence speech production rate, we hypothesize that a metronome-like priming rhythm will influence the rate of speech production in participants.

Study 1

In this study, participants heard a metronome-like priming rhythm and described cartoon-like pictures out loud. The goal of this study was to explore whether a metronome-like priming rhythm could influence speech production rate.

Methods

Participants

Forty-five native English-speaking undergraduates participated in our study. Of the participants 11 were male and 34 were female. The average age of participants was 18.5 years. Participants reported their race/ethnicity as 5.5% Asian, 75.9% White, 12.9% Black/African American, 1.8% American Indian or Alaska Native/First Nation, and 3.7% Hispanic or Latino.

Procedure

Each participant was assigned to a variation. Those variations were the Time variation and the Item variation. In the Time variation, length was controlled. In the Item variation, the total number of items in the prime was controlled. Each participant received a fast and a slow block in this within-subjects design study. Half of the participants received a fast block that was matched to the slow block and was controlled for the length (Time Variation). Half of the participants received a fast block that matched the slow block and was controlled for the number of items (Items Variation). The slow or fast prime was the independent variable. Rhythmic beats were presented in two blocks. In the Time variation, the slow block had 8 beats at 60 beats per minute and lasted for 8 seconds (Slow-long). The fast block had 16 beats at 120 beats per minute and lasted for 8 seconds (Fast-long). In the Item variation, the slow block had 8 beats at 60 beats per minute and lasted for 8 seconds (Slow-long). The fast block had 8 beats at 120 beats per minute and lasted for 4 seconds (Fast-short) (Figure 1).

Participants completed the conditions at a desktop computer using DirectRT software. Participants began with 5 practice trials in which they described pictures out loud, using simple sentences. The first 2 pictures had a sentence underneath and the final three pictures were unscripted. Next, participants were instructed to listen to rhythmic sounds and then describe, out loud, an animated picture with a simple sentence (Figure 2). The rhythmic sounds consisted of cowbells, drips, heartbeats, pings, and a metronome. Participants listened to one of the sounds and then described a cartoon like picture out loud for twenty-five trials. During the first block, participants listened to either faster rhythmic beats at one hundred and twenty beats per minute (Figure 1) or slower rhythmic beats at sixty beats per minute (Figure 1) in-between describing the pictures. After the first block, participants were asked to complete a demographics survey that inquired about language and musicianship. During the second block, the participants experienced the condition that they did not experience in the first block in-between describing the pictures. The blocks were counterbalanced. At the end of the second block, participants rated the sounds from one to five with five being the most pleasant. Participants were also asked to describe the purpose of the study.

Figure 1: The Variations

Time Fast Block Fast-long	Time/Item Slow Block Slow-long	Item Fast Block Fast-short
* * * * * * * * * * * * * * * *	* * * * * * * *	* * * * * * * *
120 bpm, 16 items, 8 seconds	60 bpm, 8 items, 8 seconds	120 bpm, 8 items, 4 seconds

Figure 2: One of the animated pictures described with a simple sentence

"A boy is building a sandcastle"

Results

Speech Rate

A t-test was conducted and no significant differences in speech production rate (seconds/syllables) were found. Participants did not have a significant different in speech production rate between the Time variation, $t(21) = 0.48$, $p = 0.633$, and the Item variation, $t(22)= -1.179$, $p = 0.25$.

Figure 3: Time Variation

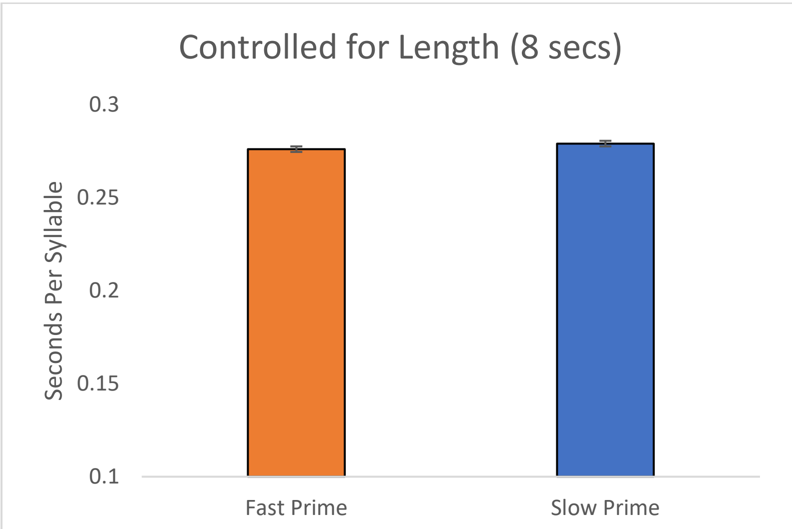
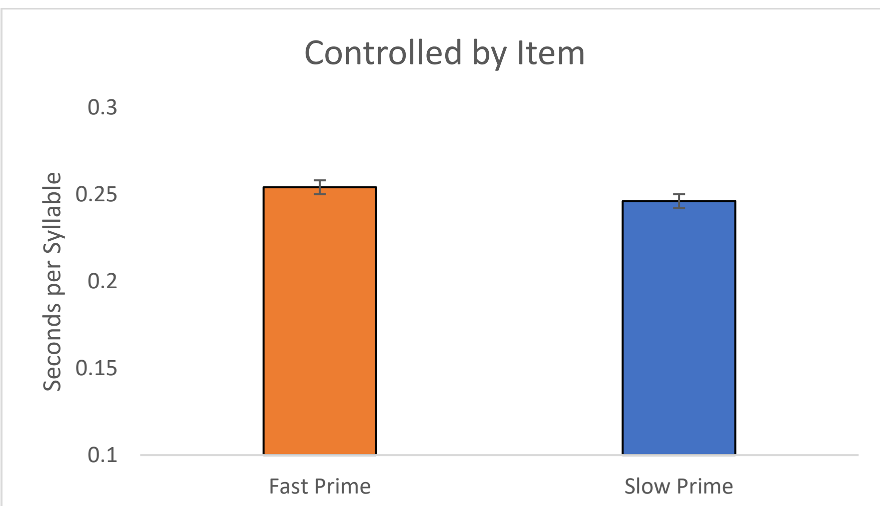


Figure 4: Item Variation



Discussion

In the current study, we found that there was no significant difference in speech production rate. The rate of the prime did not affect speech production rate in any variation. These results do not support our hypothesis. These findings were surprising because past studies with a musical or speech prime have seen an effect on speech production rate in adults and children (Jungers & Hupp, 2009; Jungers & Hupp, 2018). Our findings do not support past research. One possibility is that the metronome-like prime was not strong enough for the listener because the prime did not include enough information. Because we know that a musical prime is strong enough for an effect to take place, it is possible that a stronger prime is needed for entrainment to take place (Fujioka et al., 2010; Jungers & Hupp, 2018). The prime of another voice has been seen to improve stuttering in children (Guitar & Marchinkoski, 1991). A metronome-like prime may not be sufficient to have the same effect. Anecdotally, it was observed that participants used increased volume during the faster block and decreased volume during the slower block. Participants could have been translating the prime to affect volume instead of speech production rate.

One limitation in this study was the sample size. We had a relatively small sample size. However, this number of participants was based on previous research (Jungers & Hupp, 2018). Finally, because the results were not significant and were not in the correct direction, we do not think that a larger sample size of this study would yield a significant result.

Study 2

The second study was a between-subjects design study. It was conducted because the first study was a within-subjects design. It is possible that because the participants experienced both the fast and slow blocks in the first study that the blocks could have influenced each other. The second study is a between-subjects design so that each participant would only experience either a fast or slow condition. In this study, participants heard a metronome-like priming rhythm and then described cartoon-like pictures out loud. Reaction time was also measured in this study with a button press. The goal of the second study is to ascertain if a priming rhythm, that has no melodic component, can influence speech production rate.

Methods

Participants

One hundred and six English-speaking undergraduates participated in our study. Of the participants 48 were male and 58 were female. The average age of participants was 18.6 years. Participants reported their race/ethnicity as 1.8% Asian, 73.5% White, 16.9% Black/ African American, 0.9% American Indian or Alaska Native/First Nation, 4.7% Hispanic or Latino, and 1.8% Other.

Procedure

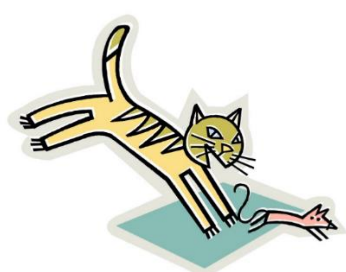
Participants were randomly assigned to one of three conditions. The conditions were Fast-short, Fast-long, and Slow-long. The fast or slow prime was the independent variable. The Fast-short condition had 8 items at 120 beats per minute for 4 seconds, the Fast-long condition had 16 items at 120 beats per minute for 8 seconds, and the Slow-long condition had 8 items at 60 beats per minute for 8 seconds (Figure 5).

Participants completed the experiment at a desktop computer using DirectRT software. Participants began with 5 practice trials in which they described pictures out loud, using simple sentences. The first 2 pictures had a sentence underneath and the final three pictures were unscripted. Next, participants were instructed to listen to rhythmic sounds and then to create a simple sentence out loud to describe a series of animated pictures (Figure 6). The rhythmic sounds consisted of cowbells, drips, heartbeats, pings, and a metronome. Participants were also instructed to press a button if the sound changed. Sixty percent of the trials had a different sound at one of several positions. Participants would listen to the rhythmic sounds and then describe the animated picture. Twenty-five trials were completed, with five of those being practice trials. At the end of the study, participants completed a demographic survey about language and musicianship. Participants were also asked to rate the sounds from one to five with five being the most pleasant and to describe the purpose of the study.

Figure 5: The Conditions

Fast-short Condition	Fast-long Condition	Slow-long Condition
* * * * * * * *	* * * * * * * * * * * * * * * *	* * * * * * * *
120 bpm, 8 items, 4 seconds	120 bpm, 16 items, 8 seconds	60 bpm, 8 items, 8 seconds

Figure 6: One of the animated pictures described with a simple sentence



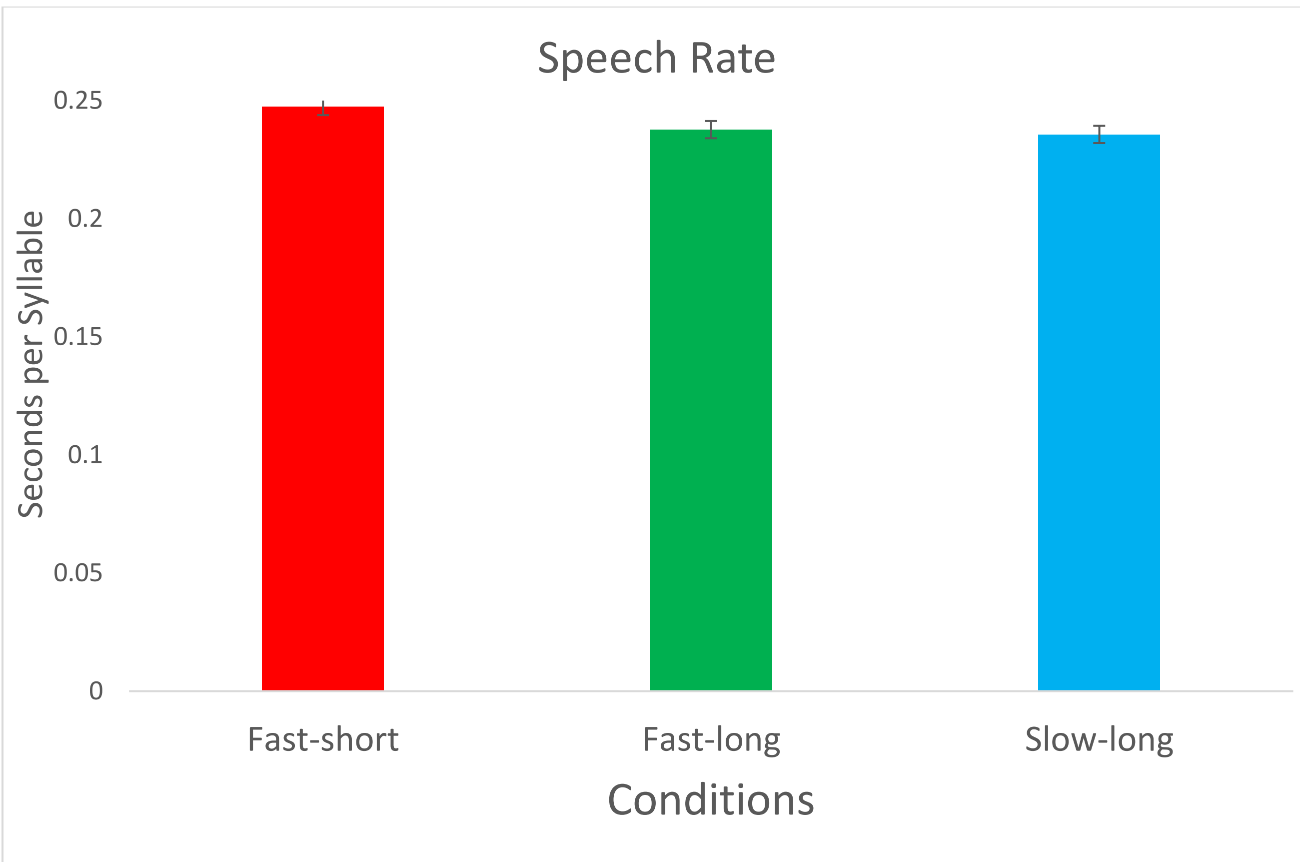
“A cat is chasing a mouse”

Results

Speech Rate

A one-way ANOVA, *F* (2, 103) = 1.025, *p* = .363, indicates that there was no significant difference in speech production rate (seconds/syllables) across the priming conditions. Participants in the Fast-short condition, (*M* = 0.25, *SD* = 0.04), Fast-long condition, (*M* = 0.24, *SD* = 0.04), and Slow-long condition, (*M* = .24, *SD* = 0.03), did not have a significant difference in speech production rate.

Figure 7: Speech Rate



Reaction Time

There was a significant difference in reaction time across priming conditions, $F\ (2, 103) = 6.947$, $p = .001$. A Bonferroni post-hoc test revealed that participants in the Fast-short condition, ($M = 576.93$, $SD = 213.31$), reacted faster than participants in the Slow-long condition, ($M = 851.34$, $SD = 397.63$), $p = .001$. Participants in the Fast-long condition, ($M = 685.22$, $SD = 281.03$), reacted marginally faster than participants in the Slow-long condition, $p = .070$.

Figure 8: Reaction Time

Discussion

The priming rate did not affect speech production rate. These results did not support our hypothesis. However, the rate of prime did affect reaction time. These results were unexpected because the goal of the study was not to evaluate the effect of the prime on reaction time. The reaction time inclusion was a manipulation check to see if participants were paying attention.

The reaction time manipulation check suggests that participants were paying attention and the metronome-like prime affected their behavior. The finding that the rate of the prime did not affect speech production rate was surprising because the past studies with a musical or speech prime have seen an effect on speech production rate in adults and children (Jungers & Hupp, 2009; Jungers & Hupp, 2018). Like in the first study, the metronome-like prime was not strong enough for the listener to latch onto which means the prime did not have had enough information for an effect to take place. It is possible that a stronger prime is needed for entrainment to take place (Fujioka et al., 2010; Jungers & Hupp, 2018).

General Discussion

Previous studies have used either a language or music prime (Jungers & Hupp, 2018; Jungers et al., 2016). Both of the current studies aimed to ascertain if a prime that does not have a music or language component can have a similar effect as the music and language primes have in the past. Both of these studies contribute to the literature because there has not been a study that does not use a music or language prime. The finding that a metronome-like prime does not have enough information to affect a listener's speech contributes to the previous research. Past studies have found that when parents slow down their speech rate with children who stutter, the children will also slow down their speech rate and their stuttering will improve (Guitar & Marchinkoski, 1991). Imitation is a way to create social bonds (Krishnan-Barman & Hamilton, 2019). A child slowing down their speech rate to match their parent's speech rate is imitation. Because of the previous findings that the rate of a musical prime affects speech production rate, it is suggested that a slower musical prime would also decrease stuttering (Hupp & Jungers, 2009; Jungers & Hupp, 2009). Therefore, our findings that a metronome-like prime does not affect speech production rate, contribute more research to what would and would not help to decrease stuttering. For example, we now know that a metronome may not help to decrease stuttering. These results add to the available research and could spark more interest in exploration of this topic.

The finding in the second study that the rate of the prime affected the reaction time of the participants contributes to the literature. One possible reason that the rate of the prime affected the participant's reaction time is entrainment. From past studies, we know that rhythmic beats influence individuals' motor behavior (Nettl, 2000). It is possible that the metronome like beat influenced the participants' reaction time because their internal rhythms aligned with the beat (Jones & Boltz, 1989; Large & Jones, 1999). The finding that the rate of the prime effected participant's reaction time was surprising because the reaction time measure was a manipulation check. It was used to make sure that the participants were paying attention during the study.

Future Directions

In the future this study could be conducted again, but with a different prime. We know from these studies that the prime needs to have more information, whether it be language or music (Jungers & Hupp, 2018; Jungers et al., 2016). Because it has been found that a musical prime has enough information to affect listener's speech production, a prime that could be used for the next study could be a prime that has a melodic or tonal component. However, a future prime should not be music. A prime that could be used for the next study could be a musical scale because a musical scale will have a tonal component, but not a melodic component. That way the prime is not quite music, but it has more information than the metronome-like prime that we used in these studies. It would be interesting to investigate how much information is needed in order for a prime to affect speech production. We know that a metronome-like beat is not enough, but a musical prime is. It would be interesting to see if a prime that is in between a metronome and music would have an effect on speech production.

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